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AN EXPERIMENTAL LABORATORY SPRAYER FOR SIMULATING FIELD CONDITIONS

by

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One engineering research project at the Southern Grain Insects Research Laboratory is concerned with insecticide applications to corn for the control of the corn earworm (Heliothis zea (Boddie)) and the fall armyworm (Spodoptera frugiperda (J. E. Smith)). Most data on the application of insecticides are obtained in the field during the growing season. Consequently, many years pass before sufficient data can be gathered for designing new equipment or for modifying that already in existence. An insecticide applicator designed for year-round use would expedite collection of these data. Therefore, in 1962 a spray applicator was designed and fabricated at Tifton, Ga. This equipment was designed to facilitate laboratory study of all components that affect the efficient application of insecticides on plants requiring insect protection.

Before design work began, laboratory-type sprayers were studied at several locations. Most laboratory-type sprayers were designed to convey plants through a stationary spray zone. This design is satisfactory for small plants but not for large ones. Mature corn plants, 5 to 7 feet tall, are almost impossible to convey through the spray zone in a manner closely resembling field conditions. A spray stand designed to convey mature corn plants would, of necessity, have to be very long to accelerate and decelerate the plants without tipping or causing injury to them in the process, especially at speeds up to 8 m.p.h. The average speed of field sprayers is 4 m.p.h., top speed is 8 m.p.h. When corn plants are moved at these speeds their foliage is displaced, and this displacement changes the target area from that normally encountered in the field.

Hence, we decided that the most satisfactory laboratory-type sprayer for mature corn plants would be one designed to pass the spray zone across the plant as is done in field operations. Other researchers have done considerable work in developing spray stands for applying herbicides and insecticides to small plants in pots or flats. Few plans are available, however, for these laboratory-type sprayers, and very little information appears in the literature. Mason and Adamson[2] constructed a sprayer with a movable spray zone which traveled 37-1/4 inches. The rate of nozzle movement and length of spray zone were fixed.

DESCRIPTION OF SPRAYER

A laboratory spray stand for applying insecticides to sweet corn ears at silking time must be easily modified to control the many variables encountered in insecticide application. The stand must be designed to cover the maximum and minimum range of the variable factors. Some of the factors that must be controlled are: Size, type, and number of nozzles and their distance from the target area; direction of nozzle in relation to plant; speed of sprayer, spray pressure, and gallonage; and orientation of ear in relation to sprayer travel. Variables in plant characteristics

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[2] Mason, E. B. B., and R. M. Adamson. A sprayer for applying herbicides to pots or flats. Weeds 10: 330-332. 1962.

affect application of insecticides and must be compensated for by adjusting the machine so that spray will be contacting the optimum target area.

A spray stand for controlling these variables was designed and constructed as shown in figures 1 and 2. Its primary components are a metal frame, pump, motors, boom carriage, boom driving mechanism, and boom. The main frame is constructed of 2- x 3- x 1/4-inch angle iron to provide adequate overhead support for the motors, pump, speed regulator, and boom driving mechanism. This frame, secured at ceiling height to the end walls of the building, is supported on each end by a 2- x 2-inch steel tube. If desired, legs for the frame could be cut to obtain any specified height. The boom travels underneath the frame at a distance of 75 inches above the ground. This feature provides adequate clearance for most sweet corn plants.

The two-piston pump, belt driven by a 1-horsepower electric motor, is capable of producing pressures up to 400 p.s.i. Undesirable pulsation caused by the piston-type pump is eliminated by the use of a surge tank. On sprayers not requiring high pressures, a roller-type pump could be used to eliminate pulsation. Liquid pressure from the pump is controlled by an adjustable bypass valve. A gauge connected into the hydraulic line indicates the pressure.

The boom carriage is made of 1/4-inch aluminum plate measuring 14 x 17 inches (fig. 3). Each of the four wheels on the carriage is mounted on ball bearings and has its rim grooved to fit a track. The top two wheels are guided by a track made from the edge of a 2- x 2- x 3/8-inch angle iron. The bottom two wheels run on a rod, 5/8-inch in diameter, spot welded to the top of a 6-inch junior I-beam, required to minimize sagging on the long span (19'-0"). A smaller beam could be used for a shorter span.

The spray-boom carriage is propelled back and forth on its track by a specially designed mechanism attached to one link of an endless roller chain drive. This mechanism allows the boom to reverse its direction of travel automatically each time it reaches a sprocket on which the roller chain travels (fig. 4). The chain is No. 50, and is 33 feet long. The sprockets over which it travels each have 112 teeth of 5/8-inch pitch. The speed of the carriage can be varied from 0 to more than 8 m.p.h. and is controlled by a variable hydraulic drive connected to one of the sprockets.

One side of the spray-boom carriage has two members attached in a manner that form a vertical slot in which the outer race of a ball bearing can move freely up and down (fig. 3). The journal on which the ball bearing can rotate is fastened to a special link in the drive chain (fig. 1). The length of slot in which the ball bearing travels up and down must be at least as long as the maximum diameter of the sprocket plus twice the length of the special link.

Figure 4 shows five positions of the ball bearing during the reversing cycle. At position 1 the carriage is traveling at the speed of the chain. The chain, moving around the periphery of the sprocket, carries the special link down around the sprocket. When position 2 is reached, the bearing has started down the slot and the boom carriage has slowed down. By the time position 3 is reached, the travel of the boom carriage is zero, and the bearing has moved half way down the slot. As the special link continues on around the periphery of the sprocket it carries the bearing further down in the slot. In position 5, the bearing has reached the bottom of the slot and the boom-carriage speed is now the same as it was in position 1, but it is traveling in the opposite direction. When the special link on the roller chain reaches the other sprocket, the procedure is repeated as the special link moves up around the sprocket.

The boom attached to the carriage extends below the track (figs. 1 and 2C). Drops on which the nozzles are mounted can be easily changed to correspond to "row width" or different plant types being sprayed.

The sprayer was designed to permit on or off control of the spray at predetermined points. Two special fingers attached to the roller chain activate a switch. The switch, when turned on,

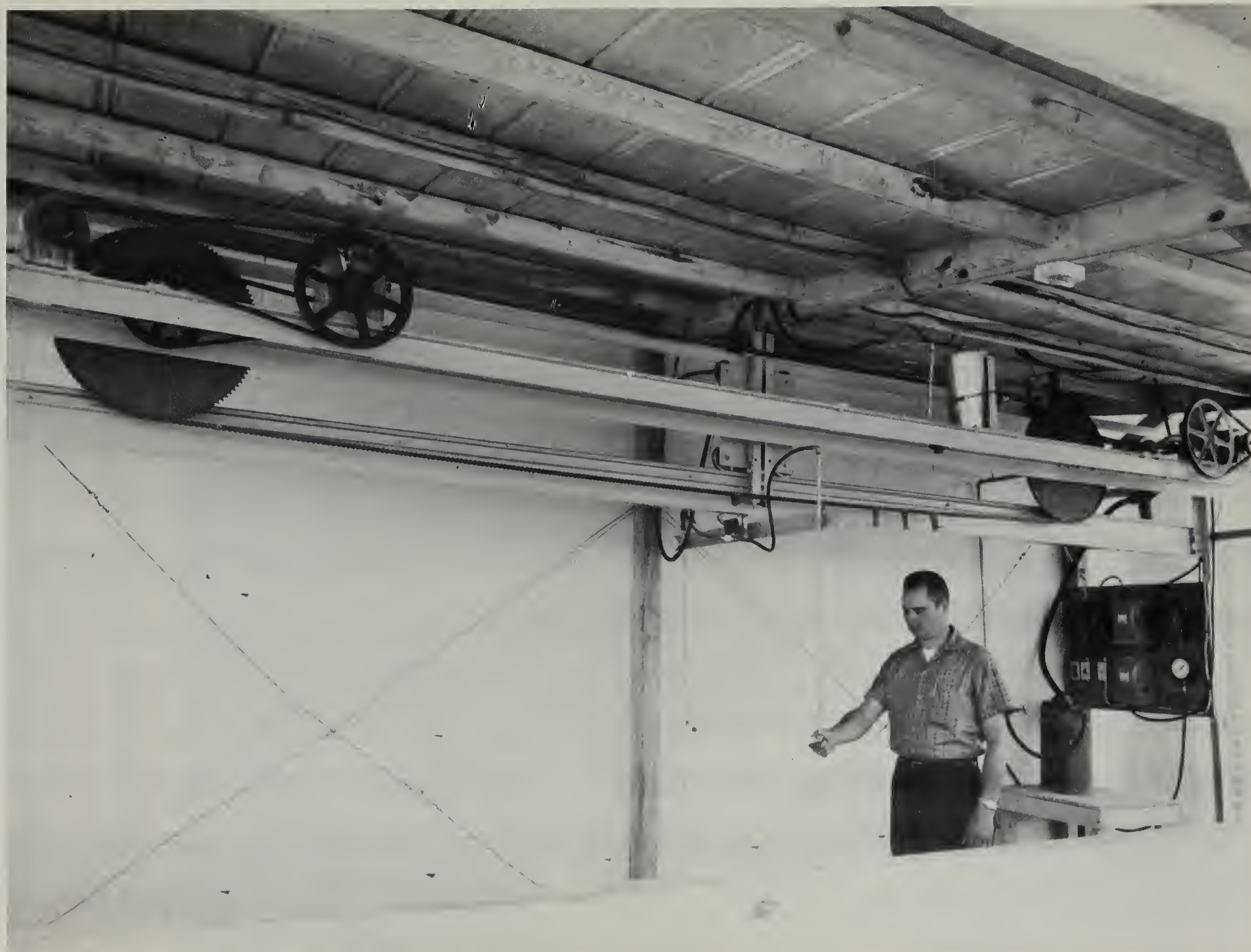
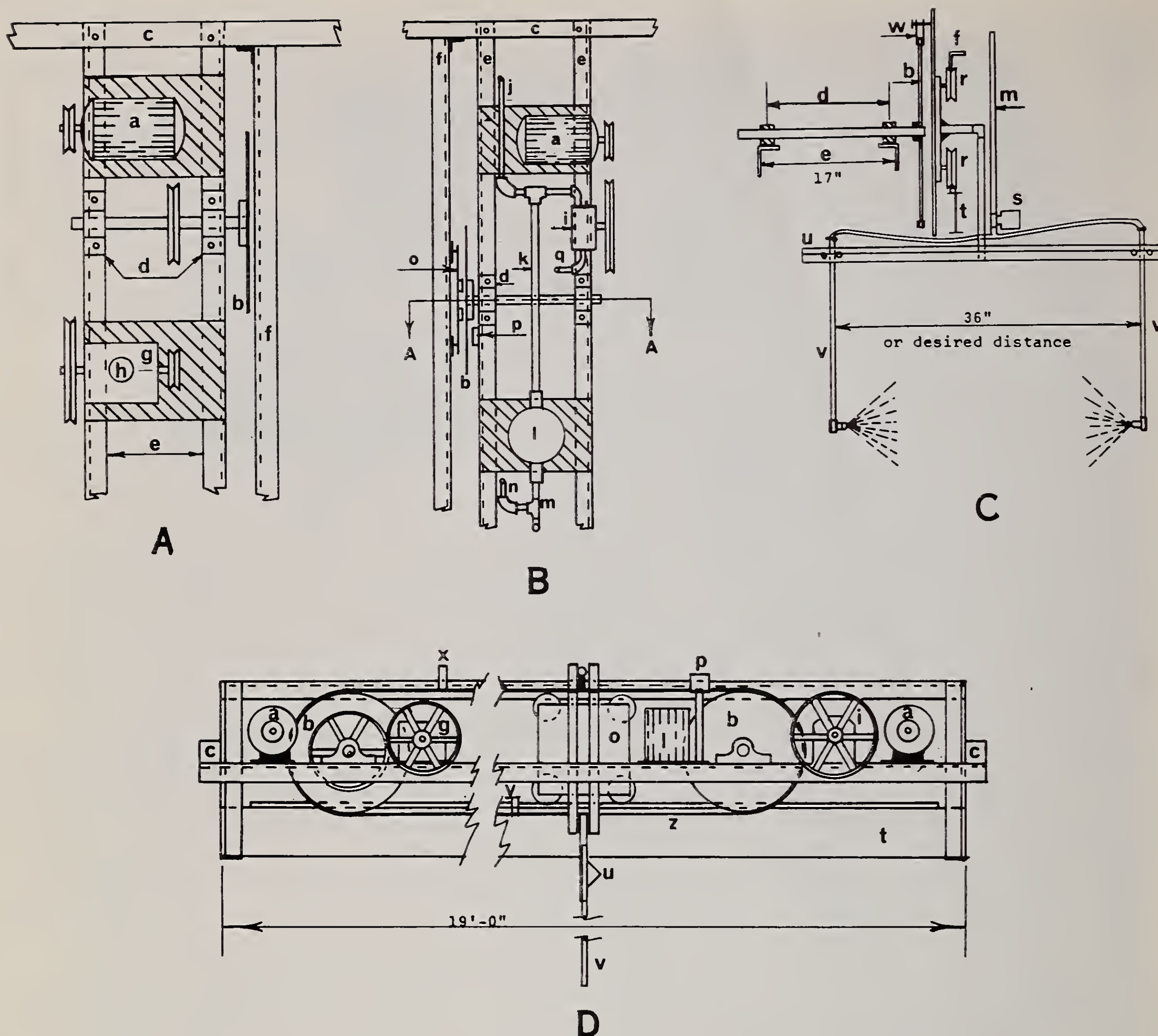


Figure 1. Experimental laboratory sprayer and control panel. Sprayer frame is mounted near ceiling and is fastened to walls of building.



a. 1-hp motor
b. 112 teeth 5/8" pitch sprocket
c. 2" square support member - cut to fit
d. pillow block bearing
e. 2" x 3" x 1/4" angle iron framing 19'-4"
f. 2" x 2" x 3/8" angle iron top track 19'-0"
g. variable speed reduction
h. speed control
i. pump
j. high pressure line to regulator and overflow
k. high pressure line to surge tank and nozzles
l. surge tank
m. flexible high pressure line to nozzles
n. high pressure line to gauge
o. carriage
p. switch to start and stop spray
q. suction line to pump
r. carriage wheels
s. solenoid valve
t. 6" junior I beam with 5/8" rod on top to form carriage track. 19'-0" long
u. 1 1/2 x 1 1/2 x 3/16" angle iron boom
v. nozzle drops
w. link attachment to move carriage
x. finger to turn on spray
y. finger to turn off spray
z. chain to move carriage

Figure 2.--Schematic diagrams (not to scale) of various parts of experimental sprayer shown in figure 1. A, top view of left end of frame and attached mechanisms; B, top view of right end; C, boom and carriage or vertical section through A-A of diagram 2B; and D, overall front view of sprayer.

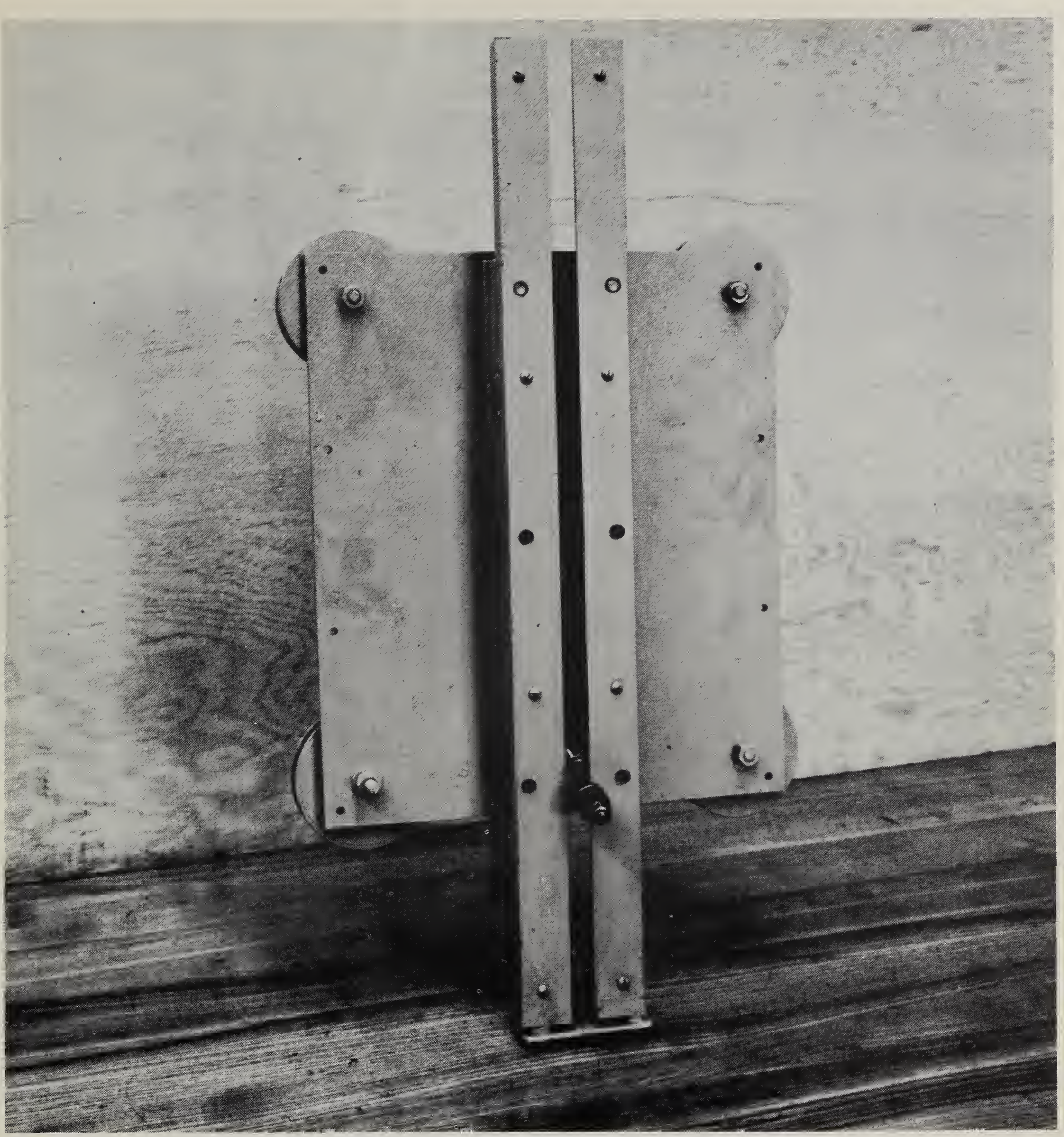


Figure 3.--Spray-boom carriage showing wheels that hold boom on its track. Note vertical slot, which is part of the carriage reversing mechanism.

energizes the two solenoid valves controlling the spray. One finger energizes the system starting the spray; the other deenergizes the system stopping the spray. The solenoid valves are installed in the pressure line as near as possible to the nozzles. When energy is applied, one valve (normally closed) opens letting liquid under pressure flow to the nozzle drops. The other valve (normally open) provides a means of relieving the pressure in the line between the first solenoid valve and the nozzles when the system is deenergized. The spring-loaded diaphram nozzles are drip proof when pressure drops below 15 pounds.

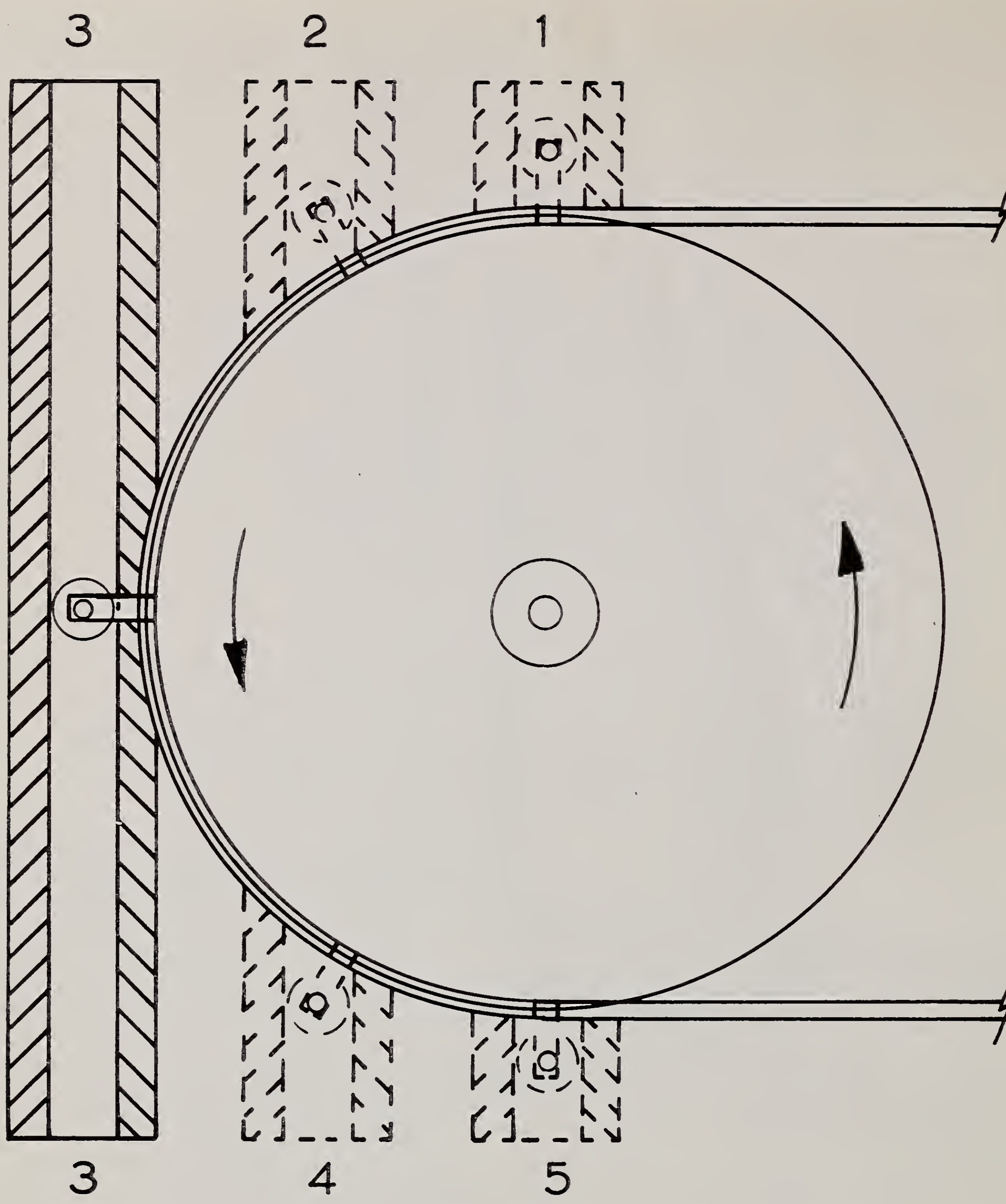


Figure 4.--Boom-carriage reversing mechanism.

OPERATION OF SPRAYER

In operating the laboratory-type sprayer, plants are placed on the center line between nozzle tips equi-distant from the limits of boom travel. Nozzles are arranged on the drops to meet the conditions of the experiment. Variations in nozzle arrangement might include the number of nozzles per drop, distance between nozzles on the drops, and the angle of nozzle to plant. The nozzle angle to the plant may be 90° from the vertical, or it may be adjusted up, down, forward, or backward. Any combination or variation of the above nozzle positions may be used.

After the system is adjusted to obtain the correct speed and pressure, the manual switch that energizes the solenoid valve circuit is turned on as the carriage approaches the starting

point. The first of the two fingers on the roller chain trips the switch, activates the solenoid valves, and starts the nozzles spraying a short distance before they reach the first plant. The second finger trips the switch again and de-activates the solenoid valves, which stop the spray immediately after the nozzles pass the last plant. As the carriage automatically returns, the switches for the motors and solenoid valve circuit are turned off manually. The plants, parts of plants, or other material being sprayed are now removed from the stand.

The cost of this installation was about $525.00. However, the cost would vary with the size of the sprayer. A smaller unit could be built at less cost. When high pressure is not required, a less expensive pump and motor could be used. If desired, compressed air or a gas may be substituted for the pump and its driving motor.

Bill of Materials

2 - 1-hp electric motor
2 - switches for motors
1 - micro switch for solenoid valve, push-on and push-off type
1 - hydraulic speed reducer, 1 1/2-hp input; input speed of 750 r.p.m. and output speed 0 to 750 r.p.m.
1 - 2 piston pump, 10 g.p.m. at 400 p.s.i.
2 - 2" x 3" x 1/4" x 19'-4" angle iron for frame
1 - 2" x 2" x 3/8" x 19'-0" angle iron to guide top carriage wheels
2 - 2" x 2" x 1/4" x 2'-0" angle iron to hold ends of track together
1 - 19'-0" x 6" Junior I-beam track for carriage
1 - 19'-0" x 5/8" steel rod
2 - 2'-0" x 1" steel shafts for sprockets
2 - 112-tooth 5/8" pitch sprockets
4 - 1" pillow block bearings
4 - 4" V-pulleys for carriage wheels
8 - #5200 ball bearings for wheels
1 - Bearing Company of America[3] #203-ss bearing for slot on carriage
1 - pressure gauge, 0-600 p.s.i.
1 - relief valve regulator
6 - V-sheaves (for motors, pump, speed reducer, and carriage drive)
2 - solenoid valves
1 - 33' No. 50 roller chain
3 - V-belts
1 - surge tank, 2 gallon capacity or larger
4 - 12" x 17" x 1/4" steel plate; base for motors, speed reducer, and surge tank
1 - 14" x 17" x 1/4" plate (aluminum or steel)
4 - 2' x 1" x 1/2" steel to form slot on carriage for driving bearing
2 - 2' x 1 1/4" x 1/8" steel to retain bearing in slot
1 - 20' of flexible pressure hose cut to required lengths
1 - suction hose
bolts as required
pipe fittings as required to connect lines

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[3] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

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